Forestry Infomart Product Development Status - Spring 2003

A. Product 1: Selection of High Conservation Value (HCV) and High Restoration Value (HRV) Forests.

Conservation efforts are often limited by constraints on time, money, and resources. Evaluation of biological and physical features within OAs (conservation opportunity areas, which are relatively large forest patches away from roads – see Synergy II report for details) can help set priorities for conservation. High priority OAs represent HCV forests. To identify HCV forests, different conservation targets may be considered important. Much dialogue has gone on among conservation biologists regarding appropriate targets, but no general consensus has been reached as to the overall importance of different targets. Earlier workers and groups such as NatureServe generally considered rare elements to be highest concern, but later the national Gap Analysis program and others focused on total species diversity. Most recently, workers within the World Wildlife Fund and others in The Nature Conservancy and academia have suggested that conservation reserves should contain representative examples of the abiotic features the landscape. With these differences in opinion regarding appropriate targets in mind, we ranked OAs using five modules that represent five different targets, each of which may be more or less important to given users. Not only can different users then use the ranking by their favorite target, but also they can see how much variation arises when different targets are considered. Ranking modules included:

Module A: Landform Representation - Representation of landforms is an approach that emphasizes conservation of enduring features as outlined by several groups, including the World Wildlife Fund and US FWS. Landform patterns correspond to and affect biota and many ecological processes such as nutrient flow, micro-climatic changes, and disturbance regimes. Additionally, landforms present a relatively stable feature for conservation since they are slow to change over time compared to shifting plant and animal populations. Basic input data for this module came from MoRAP's land cover and landform modeling efforts. Modeled landform types are intersected with the OA data layer and each OA/landform polygon is given a rank from one (high value) to *n*, where *n* is the total number of OA/landform polygons of that type. Thus, each whole OA polygon has a value for each OA/landform type polygon of which it is composed. The OA is assigned a value equal to the highest value of any OA/landform type polygon contained within it.

Module B: Vertebrate Diversity – Total vertebrate diversity has been modeled by the USGS Gap Analysis program as their primary target for conservation, which provided the basic input data. The 30-m predicted species distribution surface was intersected with the OA coverage and OA was assigned a value for vertebrate diversity equal to the highest value of any pixel it contained. We then assigned each OA an ordinal rank from one (highest modeled vertebrate diversity) to *n*, where *n* is the total number of OA polygons in the subsection.

Module C: Target Bird Diversity – Target bird diversity was modeled based on presence/absence data generate by Missouri's Breed Bird Atlas project. Workers surveyed areas equal to 1/6th of a 7.5' USGS quadrangle (approximately 25 square kilometers) and recorded all breeding bird species in that area. About 1210 random sample blocks were surveyed, and we interpolated a presence/absences surface (30-m pixel resolution) for 22 target bird species. Target birds were selected by and interagency committee headed by the American Bird Conservancy; lists initially developed by Partners in Flight served as the basis. Each OA polygon was assigned a value equal to the highest value for any 30-m pixel intersected by the polygon. We then assigned an ordinal rank from one to *n* to all OAs, where *n* is the total number of OAs in the subsection.

Module D: Rare Species and Communities - The Nature Conservancy, USFS, EPA, and others are concerned with rare biota. We used Missouri Natural Heritage Inventory data to address this potential conservation target.

Module E: Target Land Cover Representation - We reviewed a the 44-class land cover classification we generated using circa 1992 data and selected target land cover types that are known to be of high conservation concern, including glades, shortleaf pine and shortleaf pine-oak forests and woodlands, mixed hardwood forest, warm season grasslands, and wetlands (marshes, swamps, and forested wetlands). We then calculated the total number of acres within each OA. We then assigned ordinal ranks from one (largest area of target land cover type) to *n* to all OAs, where *n* is the total number of OAs in the subsection.

We found that little overlap exists in the perceived top priorities for conservation when different targets are used. This is a wholly unexpected and significant finding, since it shows that planning for conservation and development is not a straightforward matter of easily identifying areas that should or should not be developed.

The OA committee decided to move forward by using landform representation as the conservation target to identify HCV forests. The logic is that landforms, or 'enduring features,' are appropriate conservation targets because biological diversity is predicted by diversity in abiotic, physical variables. In short, (1) forest land cover patches vary in terms of biological communities, (2) this variation is predictable and is tied to subtle differences in abiotic conditions, (3) forest OAs with similar landforms will have similar communities, and these will be different from OAs over different landforms, and, therefore (4) landform representation is an appropriate targets for conserving both landforms and biological communities. Thus, we moved forward to identify HCV forests for all ecological subsections within the Ozark Highlands (Table 1).

To identify HRV forests, we identified all non-forest, non-water, and non-urban land cover within a 1-km radius buffer around the all OAs and assigned these areas a value of 1. Next, we selected those areas within a 1-km radius of the 50 largest forest OAs and assigned a value of 2. Finally, we selected the nearest neighbor for each of the 50 largest OAs, found the shortest distance between the two polygons, created a 1-km wide corridor, and assigned those areas a value of 3. Thus, forest restoration areas are near forest OAs, and are assigned greater value if they are near the 50 largest OAs and even higher value if they are within corridors between the large OAs (Table 1).

Table 1.

		High Conservation Value Forests					High Forest Restoration Value Areas		
Subsection	**Total Hectares Forest Conservation OA's**	**Priority 1 HCVF (Hectares)**	**Priority 2 HCVF (Hectares)**	**Priority 3 HCVF (Hectares)**	**Priority 4 HCVF (Hectares)**	**Priority 5 HCVF (Hectares)**	**Level 1 HRV (Hectares)**	**Level 2 HRV (Hectares)**	**Level 3 HRV (Hectares)**
St. Francois Knobs and Basins									
222Aa-a	220,012	79,123	55,626	47,940	27,543	9,780	40,388	35,781	1,225
222Aa-b	279,106	78,109	62,257	58,800	56,135	23,085	52,516	35,107	1,276
Central Plateau									
222Ab-a	627,499	164,011	156,684	158,200	124,924	23,680	224,869	49,098	2,007
222Ab-b	600,519	193,866	123,544	106,508	96,550	80,049	833,041	38,872	2,248
Osage River Hills									
222Ac	228,643	53,053	49,548	42,399	43,544	40,099	171,141	24,405	2,208
Gasconade River Hills									
222Ad	175,792	53,868	37,186	31,543	28,287	24,905	124,494	22,457	1,516
Meramec River Hills									
222Ae	253,094	64,647	61,614	54,951	43,168	28,714	52,908	18,683	956
Current River Hills									
222Af	572,758	138,418	126,147	124,578	116,628	66,987	58,914	31,022	1,179

White River Hills									
222Ag	605,627	177,219	155,938	119,410	87,975	65,085	335,997	41,089	1,772
Elk River Hills									
222Ah	44,830	14,088	10,196	7,668	7,083	5,795	41,618	24,224	1,876
Prairie Ozark Border									
222Ai	11,401	3,330	1,925	1,943	1,891	2,312	37,629	15,223	2,787
Inner Ozark Border									
222Aj	119,347	38,840	21,285	16,659	20,600	21,963	189,821	26,242	2,242
Outer Ozark Border									
222Ak-a	0	0	0	0	0	0	0	0	0
222Ak-b	26,375	7,400	6,745	5,859	3,442	2,927	20,016	13,242	1,141
222Ak-c	103,508	38,067	22,780	16,173	14,270	12,216	139,940	36,321	2,067
222Ak-d	0	0	0	0	0	0			
222Ak-e	33	0	0	0	22	10	367	575	248
222Ak-f	6,809	268	733	1,701	1,795	2,311	30,839	16,454	3,485
222Ak-j	29,583	10,701	9,410	4,652	2,572	2,246	41,833	19,054	1,968
Black River Ozark Border									
222Al	182,708	50,202	48,798	43,938	26,836	12,934	42,618	21,587	1,350
Springfield Plain									
222Am	83,664	23,935	13,617	13,574	15,456	17,081	374,501	32,713	3,285
222An-c	135,813	51,486	29,697	20,476	18,698	15,457	218,718	33,241	2,627
Mississippi River Alluvial Plain									
222Ao	17,805	7,464	4,046	3,321	1,599	1,375	17,306	13,637	1,648
Missouri River Alluvial Plain									
222Ap	4,029	1,455	898	844	415	416	9,015	12,970	3,730
Illinois Ozarks									
222Aq-a	9,248	3,995	1,625	1,432	1,208	988	21,753	15,882	2,494
222Aq-b	1,759	679	311	246	297	225	6,570	1,468	
222Aq-c	20,675	6,989	4,901	4,092	2,821	1,308	1,012	9,831	1,767
Ozark Highlands Section Total	**4,445,680**	**1,296,289**	**1,023,832**	**900,405**	**753,457**	**470,400**	**3,154,452**	**613,707**	**49,215**

B. Product 2: Land Cover Classification Up-date.

Timely, regular up-dates of ETM+-based land cover data are desired by partner agencies in an effort to aid accurate decision-making, therefore leading to effective natural resource management. A flexible methodology was developed that allowed for customization of the landcover product based on partner inputs (value added landcover mapping).

Landcover mapping was based on satellite triplicates collected during the growing season (spring, summer, fall). All 30m data channels from each date were combined into a single image file. Image files that spanned the state border where clipped at ten kilometers, in compliance with the National GAP Analysis Program standard. To minimize processing, adjacent scenes were clipped to reduce overlap. A one-kilometer overlap was specified, leaving enough information to effectively edge match the adjacent scenes. An urban mask was developed in an effort to increase classification accuracy in urban areas. The mask consisted of a combination of data from the Defense Metrological Satellite Program Nighttime Lights product and population density by census block from 2000 Tiger data. The mask was applied to the satellite composite to create an urban data set and a non-urban data set. Each of the data sets was subjected to an unsupervised classification decision rule, 30 clusters specified in urban areas and 100 clusters in non-urban areas. Clusters were viewed on screen and assigned to information classes based on previous landcover maps, aerial photography, and expert knowledge. Clusters containing more than one landcover class were labeled as “confused” and set aside for further consideration. Confused clusters were subjected to cluster busting, a technique where additional clusters are specified for each confused cluster, in an attempt to alleviate the confusion present. Cluster busting is applied to each scene once. If confusion still exists, post hoc techniques are implemented to eliminate the confusion. Post hoc techniques use additional thematic layers to aid the classification procedure. Which thematic layers are utilized depends on the type of confusion present within each satellite scene. This procedure is followed in a systematic fashion with priority given to geographic locations that are of interest to partner agencies.

Based on partner input, the four scenes located in southwestern Missouri were chosen as the starting point for the landcover update.

C. Product 3: Forest Change Detection Methodology.

Oak decline and the red oak borer are currently affecting large portions of the Missouri Ozarks. The challenge is that once the decline is visible on the ground, the forest stand is beyond treatment and must be salvage logged. The forest change methodologies implemented here are in response to United States Forest Service and Missouri Department of Conservation Forestry Division desires to have techniques that are able to detect subtle changes in forest health, so forest remediation measures can be applied before the stand is totally lost.

Two techniques were examined to determine if there was a preferred method to access forest change in portions of the Missouri Ozarks. The techniques chosen had to be able to identify areas of subtle change in forest health. The techniques were chosen based on input from the US Forest Service and from Dr. Steven Franklin, University of Calgary, a collaborator on the project. The Forest Service requested that we investigate a technique they have recently been working with, using Band 7 from multiple years to access forest change. Dr. Franklin suggested investigating the “wetness” component from the tassled cap transformation as a means of determining change from multiple satellite scenes. The particulars of each technique follow.

For this application, a time step of 2 years was chosen, giving us data from late August/early September of 1996, 1998, and 2000. This short time step was chosen because the view from satellite of the Missouri Ozark forests shows that vegetation regenerates rapidly. Within 5 years cut sites appear to be regenerated (Michael Schanta, Mark Twain National Forest, personal conversation). This does not mean that the trees have regenerated in only 5 years, but that the vegetation signature collected by the satellite makes it appear that the forest has not been disturbed. The time step between successive satellite scenes is determined by user needs. The change detection routines were implemented on a full scene in the heart of the Missouri Ozarks (path 24, row 34).

For the Band 7 technique, from here on referred to as B7, the B7 data collected in the spectral range of 2.09 to 2.35 microns with a spatial resolution of 30m, are extracted from multiple satellite scenes with similar anniversary dates. The B7 data are collected and deposited into the same image file to facilitate visual inspection and latter classification. The B7 image was subjected to an unsupervised clustering algorithm. Initially 100 clusters were specified. The 100 clusters were labeled according to the type of forest change that was exhibited by each cluster (Table 2). The term negative change refers to forest cutting or mortality, where the term positive change refers to forest growth.

Table 2. Forest change terms and descriptions.

Type of Change	**Description of Change**
Early Negative Change	Negative change from 1996 to 1998. No change from 1998 to 2000.
Negative Change	Gradual negative change from 1996 to 1998, and 1998 to 2000.
Late Negative Change	No change from 1996 to 1998. Negative change from 1998 to 2000.
No Change	No visible change from 1996 to 1998, or 1998 to 2000.
Early Positive Change	Positive change from 1996 to 1998. No change from 1998 to 2000.
Positive Change	Gradual positive change from 1996 to 1998, and 1998 to 2000.
Late Positive Change	No change from 1996 to 1998. Positive change from 1998 to 2000.
Early Negative Change/Late Positive Change Negative	change from 1996 to 1998. Positive Change from 1998 to 2000.
Early Positive Change/Late Negative Change	Positive Change from 1996 to 1998. Negative change from 1998 to 2000.

It was determined that the inclusion of non-forested areas in the cluster determination resulted in confusion when the operator tried to assign labels. It was decided that the forest areas should initially be masked out to determine the true power of the change methods. A forest mask was generated using classifications that had previously been done for the state of Missouri. They included, the Land Use Data Analysis (LUDA) classification, the Missouri Gap Analysis classification, and the National Landcover Dataset (NLCD) classification. Only those areas that were labeled as forest in all three classifications were included in the forest mask. A more suitable forest mask will be available once the landcover update for this region is complete. After masking, only 75 clusters were required to adequately characterize the B7 scene. The assignment of labels to the forested areas was much less difficult due the masking procedure.

The same set of imagery used for the B7 procedure was also used for the Tassled Cap Wetness procedure, from here on referred to as TCW. The Wetness component from each scene's tassled cap transformed datasets are collected and deposited into the same image file to facilitate visual inspection and latter classification. The same classification procedures used for the B7 routine were applied to the TCW routine. Initially 100 clusters from an un-masked scene were implemented with similar confusion as that discussed above encountered. The scene was then masked and 75 clusters were specified. The assignment of cluster labels more straightforward after the masking procedure.

The change maps from each of the procedures do an adequate job of identifying areas where change in forest makeup is occurring. There are areas where the change detailed in the change maps from each of the procedures is very similar, and areas where the degree of change represented are very different. The change delineated with the TCW procedure appears to be more sensitive to subtle changes in forest composition as compared to the change delineated using the B7 procedure. These results are currently being field checked by Forest Service personal to determine if the change represented by the TCW procedure is in fact change, or possibly just associated with noise generated by the tassled cap transformation procedure.

D. Product 4: Forest Productivity Modeling.

The US Forest Service and the Missouri Department of Conservation have shown interest in modeling forest productivity for the Missouri Ozarks. This ability is significant in Missouri because many Ozark forests were historically shortleaf pine or mixed pine-oak, which are more productive given the same abiotic conditions versus the current oak-dominated vegetation types. As part of the Synergy II project, we visited Ray Hunt, an ecosystem modeler with the USDA, at his office near Washington, D.C. We discussed requirements for implementing his forest productivity model, BGC++, and he agreed to work with us to implement the model for selected areas in the Missouri Ozarks. The required abiotic input data for the model runs were collected from multiple sources (Table 3). The Mark Twain National Forest (MTNF) supplied forest stand polygon information. These data were invaluable because they served as the basic unit within which productivity measures were calculated.

Table 3. BGC++ required parameters and source.

BGC++ Parameter	Source
Biome type	MTNF stand database
Latitude	MTNF stand database
Longitude	MTNF stand database
Soil texture	STATSGO database
Soil depth	STATSGO database
Elevation	National Elevation Dataset (NED)
Slope	NED
Aspect	NED
Biomass by species	Forest Inventory and Analysis data
Leaf Area Index by species	Cannell, 1982
Temperature	National Climate Data Center (NCDC)
Precipitation	NCDC

All data required by BGC++ was complied in an ArcView shape file to maintain the spatial link to the original forest stand polygons. BGC++ expects several input files in differing formats, each as flat ACSII files. Over 64,000 polygons were evaluated by BGC++ for the MTNF. The output from BGC++ included Total Net Primary Production (NPP), above ground NPP, and total allocation to stems (stem increment), all given in KgC/ha/yr.

MODIS/Terra Net Photosynthesis (PSN) 8-Day L4 Global data was gathered for the area coincident with the MTNF. The PSN data are measured in KgC/m^2/8 days. At some point the 8-day PSN data will be integrated over a year to produce an annual NPP product; to date, this product is not available. The PSN data was projected to UTM-zone 15 using the MODIS Reprojection Tool. The data were then imported to our image-processing package. A similar procedure was followed for each of the Quality Control (QC) masks. A total of 44 scenes of PSN data were processed. Image dates ranged from December 2, 2000 to January 25, 2001. All PSN data were masked using the supplied QC data. Only data that satisfied the following QC standard were included for further processing: 1) were deemed best possible or OK, 2) used main method to calculate Fraction of Photosynthetically Active Radiation (FPAR) and Leaf Area Index (LAI) or used empirical backup method to calculate FPAR and LAI, 3) significant clouds not present, and 4) had a Confidence Quality score of very best, good, or OK. The resulting eight weeks of PSN data were merged into a single image by taking the maximum PSN value for any given pixel.

A comparison between the modeled NPP and the MODIS derived NPP was not possible because the MODIS derived NPP data is not yet available. We did attempt to compare the modeled NPP data to the MODIS derived PSN data, but a relationship did not exist. This is most likely due to the fact that the MODIS data were collected during the winter of 2000-2001, where the BGC++ product is a yearly measure of production.